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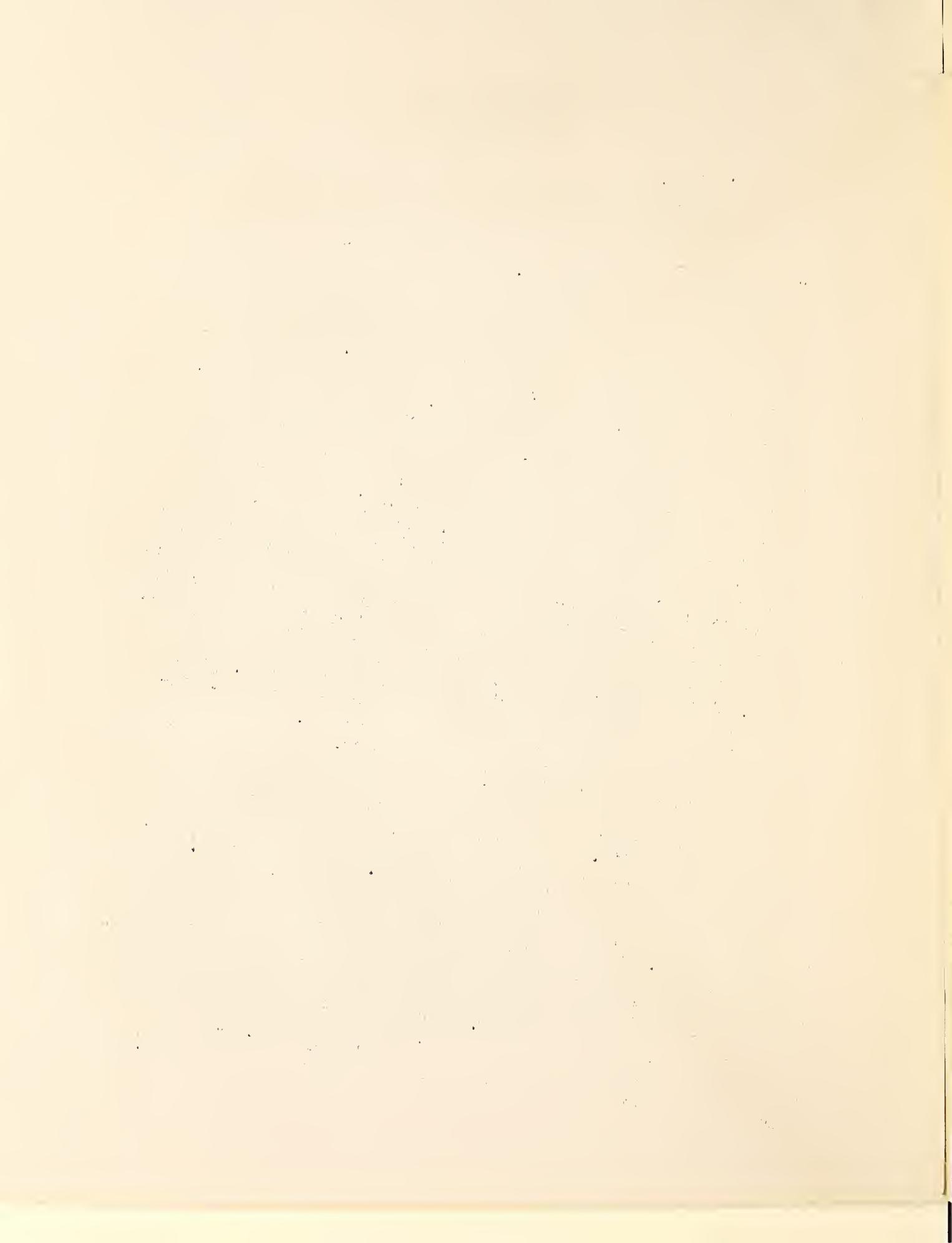
U. S. Department of Agriculture  
Weather Bureau  
Instrument Division

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Preliminary Instructions for Measuring Ceiling  
Heights with Projector and U. S. Weather Bureau Type  
Clinometer.

The Weather Bureau has recently received the first lot of clinometers, instruments for measuring vertical angles. This particular form of clinometer has been designed and developed under the personal direction of Prof. Charles F. Marvin. Specifically its purpose is to measure the angular elevation from  $0^{\circ}$  to  $90^{\circ}$  of a spot of light projected on a cloud at night. The sighting tube is nearly 3 inches in diameter at its outer end in order that not only the light spot on the cloud but a portion of the surrounding dark sky as well may be included in the field of view for contrast. A pair of cross wires aid the eye in centering on the light spot. A quadrant with scale zero to 90 degrees in whole degree graduations is rigidly attached to the under side of the tube, and a pendant is pivoted on a horizontal axis in a way to permit it to hang vertically of its own weight when the tube is sighted on an object. The zero line on the pendant matches the zero line on the quadrant when the tube is sighted on an object at the same level, and matches the 90 degree line on the quadrant when it is sighted to the zenith. A clutch operated by turning a milled head screw with the left hand clamps the pendant in position when a sight is made. This clutch operates easily and positively with only slight pressure. Observers should practice until familiar with its action. Reasonable care should be exercised not to use too much force. Readings to the nearest whole degree are sufficient.

When this device is used the projector will be adjusted to direct the light to the zenith. The horizontal distance from the point at which the observer stands to the projector is known as the base line. It has been established on a length of 500 ft. at many stations. The base line multiplied by the tangent of the angle of elevation of the spot of light as measured by the clinometer equals the height of the cloud or ceiling. It is not necessary that the projector be at the same level as the observer, a feature which is likely to be an advantage in some installations where for example it is expedient to place the projector on the roof of a building or on ground higher or lower than the position occupied by the observer. Furthermore it is not at all necessary that the base line be exactly 500 feet, and therefore advantage may be taken of local circumstances favorable to a longer base; It also becomes a simple matter to establish more than one observation point.



Choice of a base line: The clinometer is graduated to whole degrees, and errors of one degree or possibly two degrees are considered likely. Now if in the accompanying table the column of heights for a 500-foot base be examined it will be seen that the change in height per degree increases rapidly above the 60 degree part of the table. If, for example, it is desired to measure a cloud 1200 feet high, the 2 degrees of uncertainty in the instrument will result in a corresponding uncertainty in the height of 230 feet for a 500-foot base line, 150 feet for a 1000-foot base line, and 130 feet for a 1500 foot base line.

From this it is apparent that since the accuracy of the angular measurement is fixed by the limits of the instrument, the accuracy of the height determination may be increased by choosing a longer base line. However practical considerations set rather definite limits. It is not ordinarily wise to run an electric line farther than 500 feet because of the cost and also because there is an important drop in voltage on such extensions, sometimes not recognized in the selection of the lamp. Since 500-foot electric extensions are already installed at a large number of stations it seems best to retain 500 feet as the standard base line for the present. At the same time a second observation point should be established by careful measurement 1000 feet distant horizontally from the projector, and the spot marked for identification. The observer will walk to the 1000-foot station when the clouds are found to be at a high angle.

A 1500-foot column has been included in the table for the use of a special station located in a valley near high mountains, where the determination of clearance above the mountain justifies the employment of unusual measures. However it is believed that frequent occasions will arise at other stations for the use of a 1500-foot base line, and an observation point is easily established.

It is understood that practically all projectors can be adjusted to project a vertical beam. Verticality in transverse directions may be checked by temporarily setting up two poles with cross arms, and sighting suspended plumb lines against the beam.

For the present these clinometers will be supplied only to stations that have projectors and lack other means of measuring angular heights.

Washington, D. C.  
August 14, 1930.

B. C. Kadel,  
Chief of Division



Height of Cloud or Ceiling, Feet, Light Beam Projected Vertically.

Angle	Tan.	Base	Base	Base	Angle.	Tan.	Base	Base	Base
		500'	1000'	1500'			500'	1000'	1500'
		h	h	h			h	h	h
5	.08749	44	87	131	45	1.0000	500	1000	1500
6	.10510	52	105	157	46	1.0355	518	1036	1554
7	.12278	62	123	185	47	1.0724	536	1072	1608
8	.14054	70	141	211	48	1.1106	556	1111	1667
9	.15838	79	158	237	49	1.1504	575	1150	1725
10	.17633	88	176	264	50	1.1918	596	1192	1788
11	.19438	97	194	291	51	1.2349	618	1235	1853
12	.21256	106	213	319	52	1.2799	640	1280	1920
13	.23087	116	231	347	53	1.3270	664	1327	1991
14	.24933	124	249	373	54	1.3764	688	1376	2064
15	.26795	134	268	402	55	1.4281	714	1428	2142
16	.28675	144	287	430	56	1.4826	742	1483	2225
17	.30573	153	306	459	57	1.5399	770	1540	2310
18	.32492	162	325	487	58	1.6003	800	1600	2400
19	.34433	172	344	516	59	1.6643	832	1664	2496
20	.36397	182	364	546	60	1.7321	866	1732	2598
21	.38386	192	384	576	61	1.8040	902	1804	2706
22	.40403	202	404	606	62	1.8807	940	1881	2821
23	.42447	212	424	636	63	1.9626	982	1963	2945
24	.44523	222	445	667	64	2.0503	1025	2050	3075
25	.46631	232	466	699	65	2.1445	1072	2144	3216
26	.48773	244	488	732	66	2.2460	1123	2246	3369
27	.50953	255	510	765	67	2.3559	1178	2356	3534
28	.53171	266	532	798	68	2.4751	1238	2475	3713
29	.55431	277	554	831	69	2.6051	1302	2605	3907
30	.57735	288	577	865	70	2.7475	1374	2743	4122
31	.60086	300	601	901	71	2.9042	1452	2904	4356
32	.62487	312	625	937	72	3.0777	1539	3078	4617
33	.64941	324	649	973	73	3.2709	1636	3271	4907
34	.67451	338	675	1013	74	3.4874	1744	3487	5231
35	.70021	350	700	1050	75	3.7321	1866	3732	5598
36	.72354	364	727	1091	76	4.0108	2006	4011	6017
37	.75355	377	754	1131	77	4.3315	2166	4332	6498
38	.78129	390	781	1171	78	4.7046	2352	4705	7057
39	.80978	405	810	1215	79	5.1446	2572	5145	7717
40	.83910	420	839	1259	80	5.6713	2836	5671	8507
41	.86929	434	869	1303	81	6.3138	3157	6314	9471
42	.90040	450	900	1350	82	7.1154	3558	7115	10673
43	.93252	466	933	1399	83	8.1443	4072	8144	12216
44	.96569	483	966	1449	84	9.5144	4757	9514	14271
					85	11.430	5715	11430	17145
					86	14.301	7150	14301	21451

